

Winter cover crops before late-season processing tomatoes for soil quality and production benefits

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Objectives

1. Document the contribution of a winter leguminous cover crop to plant nutrition, yield and fruit quality in processing tomatoes in an on-farm field trial.
2. Document the impact of a winter cover crop on soil permeability and winter runoff vs. fallow, pre-bedded ground.
3. Educate other growers and support industry about trial results and cover cropping technique.

Summary

A single fall planting of a leguminous cover crop of vetch/pea mixture increased fruit yields of processing tomatoes by 5 to 13%. Nitrogen benefit from the leguminous cover crop appeared limited. Effects on soluble solids fruit quality were inconsistent between years. Rainfall run-off during the early spring was reduced up to 70% compared to the conventional, weed-free bed approach. Some growers have since adopted the planting of a leguminous mix of cover crops ahead of cropping to tomatoes. The yield increases occurred only when grown succeeding tomatoes in the crop rotation. In our Meridian-located test, when tomatoes followed rice in the rotation, we observed no yield benefit from the cover crop program.

Introduction

Planting fall cover crops in fields that will later be planted to processing tomatoes is a departure from the conventional cultural practice among tomato growers of minimizing weed vegetation prior to seedbed preparation. Vegetation-free beds facilitate seedbed preparation especially with direct seeded tomatoes. Fall bedding coupled with clean beds increases rainfall run-off once soils become saturated.

Work Description

: Winter Cover Crop Trial

The purpose of this task is to document the nutrient and soil quality and soil conservation benefits of a fall-planted leguminous cover crop on an ordinarily winter-fallowed field ahead of late-spring-transplanted processing tomatoes on two sites Yolo and Sutter Counties, CA. The product of this task will be ongoing soil and foliar N measurements during different stages of cover crop and following cash crop development as well as yield and fruit quality data.

Month of initiation: 11/99

Month of completion: 12/00

After bed preparation, sample residual soil nitrate-nitrogen in the Yolo and Sutter fields to 3 feet. Samples will be taken at 1' intervals from soil within each replication and sent to the University of California's Division of Agriculture and Natural Resources (UC DANR) lab for analysis of presence of nitrate-N. *Completed by fall of 99.*

At both sites, the cover crop (Common vetch and winter pea mix) will be planted at 60#/A with a grain drill on 60" beds with eight treatments, each 3 rows wide and 100' long and replicated 6 times. *[Treatments are either cover cropped or fallow, with different levels of fertilizer sidedress-banded at layby (after transplanting). The treatments are: 1) no cover crop and no fertilizer; 2) no cover crop with 50#/A of nitrogen applied in spring; 3) no cover crop with 100#/A N; 4) no cover crop with 150#/A N; 5) cover crop with 0# N; 6) cover crop with 50# N; 7) cover crop with, 100#N; and 8) cover crop with 150# N.]* See charts below for the layout of each field. *Task completed by 11/99.*

Tissue sample cover crop contribution from vetch and from peas from each replication. Submit to UC DANR lab for nitrate-N sampled immediately prior to cover crop incorporation. *Completed by 5/00.*

Incorporate cover crop. *Completed by 5/00.*

Before layby fertilization, soil sample each block amongst cover crop vs fallow bed plots for nitrate N analysis at UC DANR lab. *Completed by 5/00.*

Growers to transplant tomato crop and UC to sidedress-band fertilize at layby according to treatment plot plan. *Completed by 6/00.*

Evaluate irrigation water for NO₃ three times during irrigation season. *Completed by 9/00.*

Sample tomato petioles for nitrate N and whole leaves for % total N from each plot at early bloom stage for tissue nitrogen analysis at UC DANR lab. *Completed by 6/00.*

Sample tomato petioles for nitrate N and whole leaves for % total N from each plot at full bloom stage for tissue nitrogen analysis at UC DANR lab. *Completed by 7/00.*

Sample tomato petioles for nitrate N and whole leaves for % total N from each plot at 10% ripe fruit stage for tissue nitrogen analysis at UC DANR lab. *Completed by 8/00.*

Measure marketable fruit yield and fruit color and brix of plots at harvest with UCCE weighing gondola trailers and growers' harvester. *Completed by 10/00.*

Visually assess peelability of marketable fruit. *Completed by 10/00.*

After harvest, sample soil for nitrate-N analysis at UC DANR lab. *Completed by 10/00.*

Measure impact of cover crop on soil aggregate stability and water infiltration in field

The purpose of this task is to assess potential benefits of soil quality as well as erosion control and increased infiltration due to the cover crop. The resulting data will be incorporated into the final report due to CDFA no later than 12/00.

Compare run-off flow rates and sediment load between 3 grouped cover cropped furrows and 3 grouped fallow furrows during winter storm event. *Initiated by 1/99 and completed by 4/00.*

Measure infiltration of applied irrigation water through ring infiltrometer and compare inflow and outflow during two irrigation events. *Initiated by 7/99 and completed by RCD by 9/00.*

Assess relative soil aggregate stability of cover crop vs fallow bed treatments by water stable aggregate measurements. To be performed by Jeff Mitchell of UCCE. *Completed by 11/00.*

Observe cover crop impact on winter and crop season weed management

The purpose of this task is to assess potential benefits and problems associated with weed control in a winter cover crop.

In both fields, measure and compare dry weights of cover crop and weeds in 20 1-meter-square quadrats in fallowed and cover cropped portions of the fields shortly before incorporation. *Completed by 4/00.*

Publish the results of the study in relevant ag media, and develop and conduct field days and tours on the results and information gained on winter cover cropping before late-season tomatoes.

The purpose of this task is to share information with growers, PCAs and processors to add to the existing information base and hopefully encourage by example the adoption of a winter cover cropping program. Hold two field meetings in spring and summer, followed by a paper to be submitted to agricultural press and results presented at the following Lower Sacramento Valley Tomato Production Meeting in January 2001. Month of initiation: 1/00 Month of completion: 2/01

Plan field meeting for before or after incorporation of cover crop in early spring 2000: 1) outreach/promotion, 2) topics and registration, 3) logistics, and 4) materials development. *Completed by RCD by 2/00.*

Present field meeting in spring 2000. The meeting will provide demonstration of planting, management, and incorporation techniques for cover crop as well as current information gathered during the study: N available, infiltration, runoff, soil aggregate stability, weed suppression, and other observations made. The participants will be surveyed to assess their interest in the practice and any change as a result of the field meeting. *Completed by 6/00.*

Plan mid-season field meeting to allow industry to observe cover crop impact on tomato plant vigor and yield. *Completed by 7/00.*

Hold field meeting prior to harvest in July/August 2000. *Completed by 9/00.*

Develop paper from data collected during trial to submit to agricultural press and local papers and to be presented at annual Lower Sacramento Tomato Production Meeting in January 2001. *Completed by 2/01.*

Field tests in 1998, 1999 and 2000 in the southern Sacramento Valley near Woodland were established with fall plantings of a common vetch-pea mix. Trials were 3-acre plantings in commercial fields with cooperator Blake Harlan of Harlan and Dumars. The cover crop was drilled into dry beds in the fallow period between two consecutive rotations of tomatoes. Field length strips were always planted alongside of our replicated trial to evaluate rainfall run-off. The cover crops were germinated with late fall rains. As expected, in all years, cover crop growth was slow during the winter and early spring. The peas were able to grow and develop during the cooler temperatures, compared to vetch, which grew more rapidly during late February and March. Vetch normally reaches maximum growth by early April in the Sacramento Valley. In all years, greenhouse-grown tomato plants were transplanted between late March to April.

During the late fall, we measured rainfall run-off in field-length runs, tying 3 consecutive furrows into a sump. Boat-type, automated bilge pumps pumped the collected water through flow meters. Four pumping systems, 2 each for the cover crop and the fallow treatments, were used to measure the run-off. The bilge pump system was established too late to collect data in our first year. During the 1st two seasons, a weir-based measurement system (Stevens Stage Recorders®) were set up, but resulted in limited success.

Field plot design was a randomized complete block with 6 replications with each plot 3 beds wide by 100 feet long. Two factors were evaluated: 1) fallow vs. cover cropping with a vetch-pea mix and 2) spring-applied sidedress nitrogen rates of 0, 50, 100, or 150 pounds of N per acre. Sidedressed N, as urea, was applied soon after transplants were well established. All other cultural practices were those common to the local area. Irrigation was primarily with the furrow method. Rainfall helped establish the transplants in 1998. Sprinklers were used to establish the transplants in 1999 and 2000 and furrow irrigated thereafter.

We monitored N status of the tomato plants during the season. Plant tissue samples, petiole as well as whole leaf, were collected at 3 separate growth stages and sent to the UC DANR

lab at Davis. Tomato yields suffered when grown solely on the nitrogen fixed by the vetch-peas and without benefit of supplemental applied N. We did not see a substantial fertilizer N benefit from the cover crop nor detect large N differences in tissue levels. Analysis of the cover crop indicated 100 pound of N was fixed in 1998 even with an early plow down in mid March. In 1999 and 2000, over 200 pounds of nitrogen was fixed by the leguminous plants. In 2000, the vetch and peas established well with the fall rains, but suffered with a dry December and January. Vetch was more drought tolerant and became the dominant species.

In the first year, the cover crop was purposely desiccated with a herbicide and incorporated with conventional equipment in mid March to accommodate an earlier planting schedule. In 1999 and 2000, a Wilcox Performer® bed mulcher was specifically designed to incorporate the cover crop. The ease of cover crop incorporation was different between the two years due primarily to soil moisture. In 1999, the bed mulcher chopped & incorporated the cover crop in two passes and repeated a week later in a single pass for final incorporation and bed shaping. In 2000, multiple passes were required in addition to a pre-irrigation. An early termination of the crop may have been preferable. Disking the vetch/pea mix and re-bedding was also an option.

In 2000, a duplicate trial was established near Meridian in Sutter County by UC Farm Advisor Mike Cahn. The treatments and procedures were similar to Woodland, except the crop rotation followed rice (tables 8 –9).

In all years, tomatoes were transplanted about 1 to 3 weeks after cover crop incorporation.

Results

In 1998, cover cropping resulted in a 5% yield increase and a soluble solids improvement over the fallow-bed treatment (figure 1). Applied N alone did not explain the yield enhancement. We speculate that incorporation of the leguminous biomass may have been important in changing underground factors such as soil microbial activity. Soluble solids were also increased from 4.7 to 4.9% (tables 1 and 2). Fruit color was reduced from 23.7 to 24.3 as measured by the Processing Tomato Advisory Board. In 1999, yields were increased 7%, although fruit quality was reduced (figure 2 and table 2). In 2000, yields were increased by 13% over the conventional fallow bed practice (figure 3). Fruit quality was not affected (table 2).

Soil N levels were evaluated. At the initiation of the 1998 test, nitrate N levels were ~20 ppm in each of the 1st and 2nd foot following the 1997 tomato harvest (table 3). The leguminous cover crop was tilled under earlier than planned but still produced 100 pounds of N per acre. At the time of tomato transplanting, soil levels were equivalent in the cover crop and fallow treatments. By mid season, soil nitrate levels were low, but slightly higher in the cover cropped treatment. At post harvest, the residual N levels rose and were higher in the cover crop treatment, 11 vs 7 ppm.

In 1999, residual N soil levels from the 1998 tomato crop was ~20 ppm nitrate-N (table 4). N fixed by the cover crop was measured at over 200 pound of N per acre. In the early spring, the nitrate-N levels were slightly higher in the fallow compared to the cover crop treatment, 6 vs 3 ppm. Beyond that point, there were no statistically significant differences between the cover vs fallow treatment. Ammonium levels were low (table 5).

In 2000, residual N was high with over 40 ppm nitrate-N left over in the top foot from the 1999 tomato crop (table 6). N fixed by the cover crop was again over 200 pound of N per acre. In

the early spring through mid season, nitrate levels were higher in the fallow treatment compared to the cover crop, 13 vs 6 to 11 ppm. The post season levels were similar to each other, around 10 ppm nitrate-N.

In none of the years and sampling periods was petiole nitrate-N or percent N from whole leaf tissue ever higher in the cover crop treatments compared to the fallow although the reverse sometimes occurred (table 1 and 2).

In 1998, during the El Nino weather-related year, our furrow weir-type equipment did not perform in the limited slope in the drain end of the field. Subsequently, rainfall ceased before a new system was designed to overcome the obstacle.

In February and March 1999, we compared runoff from grouped sets of field-length (~1300') rows of cover crop and fallow beds. Seasonal runoff from the cover crop furrows was ~60% compared to the fallow furrows (figure 4). In year 2000, runoff was ~22% in the cover cropped section compared to the fallow beds on field length runs of ~2100 feet (figure 5). The combined two-year rainfall run-off average resulted in over a 50% reduction (table 7).

In the Meridian trial, crop tissue levels were similar between fallow and cover crop treatments (figure 6). Yields only responded well to springtime-applied sidedress nitrogen (figure 7, tables 11-12)). There was no response to the cover crop treatment. The legumes fixed ~100 pounds of N per acre (table 10). Soil nitrate N levels were similar between the fallow and cover cropping at the 1 and 2 foot depths (figure 8). No benefit was observed when the tomatoes followed rice in the crop rotation.

Discussion

We anticipate winter-grown cover cropping may be attractive to tomato growers transplanting after late April. This planting period will maximize vegetative growth of the vetch cover crop and leave sufficient time to incorporate the green manure crop. The delay in planting misses only the earliest harvest schedules.

In each of the years of the Woodland-located trials, where tomatoes succeeded tomatoes in the annual crop rotation, yield was increased when a cover crop was grown and incorporated ahead of the cash crop planting. Normal rates of applied N appear to be required rather than relying on the leguminous cover crop to supply a portion of the N. Tomato yields were not increased by cover cropping when tomatoes followed rice in the rotation. The flooded conditions associated with rice production are unique and may be a factor.

Cover cropping reduced winter rainfall run-off from fields and may provide regional benefit to reduce local flooding in high rainfall years. An associated reduction in topsoil sediment loss can also be expected.

The cost of the cover cropping practice was economically beneficial as expense is estimated at ~\$75 per acre. A 2-ton tomato gain would pay for the added expense. Timely rainfall is needed to establish the cover crop early in the fall as well as to sustain growth through the early spring. The delay in tomato planting is also a consideration. The additional tillage required to incorporate the cover crop can be costly and less manageable than the clean, fallow bed practice. The program has a better fit for growers who transplant to establish a tomato stand rather than direct seed.

We've disseminated information in a variety of ways. One to two field meetings were held at the Woodland trial sites in each of the 3 years to show the cover crop tillage practices and later to highlight tomato crop development prior to harvest. The cover crop research findings were

presented at UCCE-organized grower production meetings held in the Sacramento Valley and the upper San Joaquin Valley in each of the 3 years. We've participated in FREP annual conferences. We were invited to speak at the California chapter of the Agronomy Society of America. A paper was presented at the International Society of Horticultural Science sponsored Tomato Symposium in Sacramento. Several growers have since adapted using some cover crops in their rotation.

We are enthused that cover cropping for a single winter period provided the yield benefit the following spring as well as reduced rainfall run off. Future plans are to follow how cover crops might fit into a reduced tillage system for California.